Hip mobility is a clinically meaningful driver of pain reduction in CNLBP: Evidence from IMUs and Markerless Systems Analysis – A Pilot Study

Background: Chronic nonspecific low back pain (CNLBP) is associated with altered lumbopelvic mechanics and reduced hip mobility [1,2]. Although hip motion deficits have been linked to persistent symptoms [3], the relationship between changes in hip flexion and clinical outcomes during rehabilitation remains incompletely understood. In parallel, markerless motion capture systems have emerged as accessible tools for movement assessment [4], although their agreement with established clinical measurement approaches requires further investigation.

Objective: To investigate the association between changes in active hip flexion and pain intensity during rehabilitation in individuals with CNLBP and to examine the agreement between a machine learning–based markerless motion capture system and inertial measurement units (IMUs).

Methods: Eleven participants with CNLBP completed a 6-week therapeutic exercise program. Hip flexion at symptom onset was assessed longitudinally in a standardized supine position using IMUs [5,6] and a markerless motion capture system [7]. Pain intensity was recorded using the Visual Analog Scale (VAS). Associations between biomechanical and clinical changes were examined using correlation analyses, while agreement between measurement systems was assessed using Bland–Altman analysis.

Results: Hip flexion increased over the rehabilitation period, accompanied by reductions in pain intensity. Strong agreement was observed between markerless and IMU-derived measurements ($r = 0.85$). Bland–Altman analysis demonstrated a small systematic underestimation of hip flexion by the markerless system (bias = −3.44°; limits of agreement: −9.71° to 2.32°). Improvements in hip flexion were moderately associated with reductions in pain for both markerless-derived ($r = -0.54$) and IMU-derived measurements ($r = -0.59$).

Discussion: The findings suggest that improvements in symptom-provoking hip flexion may be associated with reductions in pain during rehabilitation in individuals with CNLBP [8]. Furthermore, the markerless system demonstrated the ability to detect clinically relevant movement changes while showing acceptable agreement with IMU-derived measurements [9]. These findings support the potential clinical utility of both technologies for longitudinal movement assessment in rehabilitation settings [4,9,10].

Limitations: The pilot design, small sample size, absence of a control group, and lack of comparison with a laboratory-based optical motion capture system limit the generalizability of the findings.

Conclusions: This pilot study supports the feasibility of integrating objective motion analysis into CNLBP rehabilitation. Future studies involving larger cohorts, control groups, and laboratory-based reference systems are warranted to further investigate the clinical relevance of hip mobility changes and the applicability of markerless motion capture technologies.

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